

4. PRODUCTION, IMPORT, USE, AND DISPOSAL

4.1 PRODUCTION

Plutonium exists in trace quantities in naturally occurring uranium ores (Weast 1980). Plutonium is produced by the bombardment of uranium with neutrons. The most important isotope, plutonium-239, is produced in large quantities from natural uranium in nuclear reactors (Weast 1980). Plutonium-240, -241, and -242 are produced from successive absorption of neutrons by the plutonium-239 atoms. The successive absorption of two neutrons rather than one by uranium leads to the production of plutonium-238. Plutonium-237 is usually produced by the helium ion bombardment of uranium-235.

During neutron bombardment of plutonium-239 and -241, fission occurs in addition to neutron capture. With plutonium-239 about 70% undergoes fission, while the remainder is transmuted to plutonium-240. With plutonium-241, 20% undergoes fission and the remainder is transmuted to plutonium-242 (Choppin and Rydberg 1980).

The plutonium in spent uranium fuel from light water reactors (LWR) is 56% plutonium-239, 26% plutonium-240, 12% plutonium-241, 5% plutonium-242, and 1% plutonium-238 (Choppin and Rydberg 1980). This composition will vary with other types of reactor fuel, but this type is the most common in reactors operating in the United States.

As of 1980, the world's nuclear power reactors were producing more than 20,000 kg of plutonium per year (Weast 1980). In addition to these, the United States Department of Energy (DOE) has operated nuclear reactors to produce nuclear materials for the nation's defense program. These include plants at Savannah River, South Carolina, and the Hanford Works in Richland, Washington.

4.2 IMPORT

There is no information on the importation of plutonium. However, small quantities of nonweapon plutonium have been produced at the Atomic Energy Commission's (now Department of Energy) production reactors for foreign sales (Liverman et al. 1974).

4.3 USE

The majority of the plutonium, in the form of plutonium-239, is used as an ingredient in nuclear weapons. As a result of the atmospheric testing of these weapons during the 1950s, plutonium has been dispersed throughout the atmosphere. An estimated 400 kCi (1.5×10^{16} Bq) plutonium-239 and -240 were produced during weapons testing, of which approximately 325 kCi (1.2×10^{16} Bq) was globally dispersed (Bennett 1976a). Four hundred kCi of plutonium-239 weighs approximately 4,600 kg. Approximately 100,000 kCi (3.7×10^{12} Bq)

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plutonium have been dispersed within our environment from about 400 nuclear explosive tests, including those by the United States, Great Britain, and the Soviet Union between 1945 and 1963 (Facer 1980).

The nuclear reactors at the Richland and Savannah River plants were built to produce nuclear materials for the nation's defense program. The amounts of plutonium involved in the weapons program are necessarily classified.

Plutonium-238 is used as a heat source in thermo-electric power devices, such as have been employed on various satellites and had been proposed for powering artificial hearts (Bair and Thompson 1974). The estimated total quantity of plutonium-238 required for these applications through the year 2000 ranges from 25 to 75 kg (430 to 1,300 kCi; 1.6×10^{16} to 4.8×10^{16} Bq) (Liverman et al. 1974).

4.4 DISPOSAL

Plutonium is considered a transuranium (having an atomic number greater than that of uranium) element. It has a very long radiological half-life (86 and 24,000 years for plutonium-238 and -239, respectively), and, therefore, the radioactivity diminishes very slowly. Spent nuclear fuel is not reprocessed in the United States at the present time, and the fuel must be disposed of intact (Lamarsh 1983). The usual method of disposal has been to place the fuel in suitable containers and bury them in a waste repository. Prior to 1970 solid wastes containing radioactive wastes generated by nuclear power plants were buried at commercial waste sites located at Sheffield, Illinois; Beatty, Nevada; Morehead, Kentucky; Richland, Washington; and West Valley, New York. As of 1974, approximately 80 kg of plutonium was contained in this waste (Daly and Kluk 1975).

At present, radioactive wastes are being held at the DOE facilities including those in Richland, Washington, Savannah River, South Carolina, and at other reactor sites. These transuranic wastes are stored either above ground or in shallow burial pits. Neither of these methods are intended as long-term storage solutions.